Woven fabrics and a method of forming the same

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Inventor: BEEDHAM JACK; WILDI MICHAEL LEONARD
Applicant: RIBBONS W LTD (GB)
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Abstract of **EP0123472**

A method of forming a woven fabric comprises interweaving polyester warp yarns with a plurality of weft yarns, at least some of the weft yarns being polyamide multifilament yarns impregnated with a non-cross-linked homolpolymer or copolymer of acrylic acid. After weaving the fabric is subjected to heat treatment to cause the impregnated agent to cross-link and chemically bond to the polyamide yarns, but not to the warp yarns. The resulting laterally stiffened fabric is particularly suitable as webbing for use in vehicle safely harnesses.

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(71) Applicant: 'W' RIBBONS LIMITED
The Green
Warlingham Surrey CR3 9NA(GB)

(72) Inventor: Beedham, Jack
38 Llwellyn Street
Pentre Rhondda Mid Glamorgan(GB)

(72) Inventor: Wildi, Michael Leonard
"The Laurels" Colwinstone
Cowbridge South Glamorgan(GB)

(74) Representative: Geldard, David Guthrie
URQUHART-DYKES AND LORD 11th Floor, Tower House
Merrion Way
Leeds, LS2 8PB West Yorkshire(GB)

(54) Woven fabrics and a method of forming the same.

(57) A method of forming a woven fabric comprises interweaving polyester warp yarns with a plurality of weft yarns, at least some of the weft yarns being polyamide multifilament yarns impregnated with a non-cross-linked homolpolymer or copolymer of acrylic acid. After weaving the fabric is subjected to heat treatment to cause the impregnated agent to cross-link and chemically bond to the polyamide yarns, but not to the warp yarns. The resulting laterally stiffened fabric is particularly suitable as webbing for use in vehicle safety harnesses.

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WOVEN FABRIC AND A METHOD OF FORMING THE SAME

This invention relates to a method of forming a woven fabric and to a woven fabric itself. The invention is particularly concerned with narrow fabric in the form of webbing that may be used for seat belt safety harnesses and in other applications.

Seat belts used in motor vehicles are wound onto reels when not in use and are generally guided to the reel within a pillar or other guide opening into the passenger compartment. The reels are commonly combined with a self-retracting mechanism. A long-recognised problem in the successful movement of the belts through the guide and self-retraction of the belts is that the belts tend to twist or crease at the entry into the pillar or other guide, so causing jamming of the belt system. In an attempt to try and prevent this there have been proposals to make seat belt webbing laterally stiff without affecting its longitudinal flexibility, the lateral stiffness assisting to prevent the twisting or creasing that causes jamming. Despite a number of constructions that have been proposed, to the applicants' knowledge only one laterally stiffened webbing has seen any commerical success.

This last-mentioned webbing attempts to solve the problem by using monofilament weft yarns in the webbing construction. While such monofilaments give an acceptable degree of stiffness in the lateral direction

of the webbing, problems do arise because the monofilament wefts tend to slip over the warp yarns within the fabric so causing distortion and eventual breaking of the monofilaments, particularly at the end of the webbing. Additionally, flex fatigue of monofilament yarns could lead to fracture of those yarns.

Other proposals that have not even enjoyed the partial commerical success of the monofilament weft belts have relied on the application of resins and coating materials to the webbing in order to improve lateral stiffness. However, often this also has an adverse effect on the required longitudinal flexibility of the belt by stiffening the warp yarns to the same degree as the weft yarns. Attempts have been made selectively to stiffen the weft yarns only, but although there are paper proposals to this effect, for example US-A-4370784, no commercially acceptable webbing is known.

The present invention seeks to solve this problem and to provide a commercially acceptable woven fabric having lateral stiffness such that it is suitable for use in, for example, seat belt safety harnesses, industrial safety harnesses and lifting slings.

According to the invention a method of forming a woven fabric comprises interweaving polyester warp yarns with a plurality of weft yarns, at least some of the weft yarns being polyamide multifilament yarns impregnated with a non-cross-linked homopolymer or copolymer of acrylic acid, and after weaving subjecting the fabric to heat treatment to cause the impregnating agent to cross-link and chemically bond to the polyamide yarns.

Also in accordance with the invention we provide a woven fabric comprising polyester warp yarns interwoven with weft yarns at least some of which are polyamide multifilament yarns stiffened by a cross-linked homopolymer or copolymer of acrylic acid chemically bonded to the polyamide yarns, but not to the polyester yarns.

The particular selection of yarns and impregnating

material used in the invention produces woven fabric having the required qualities. The use of multifilament weft yarns overcomes the slipping and potential fracture problems experienced with monofilament constructions. The cross-linked homopolymer or copolymer of acrylic acid that is used as the impregnating agent cross-links and chemically bonds only to the polyamide weft yarns, thus materially affecting the stiffness of those yarns. It does not chemically bond to the polyester warp yarns and indeed the degree of mechanical bonding to the warp yarns that may occur is low and, for practical purposes, negligible. Accordingly, the lateral stiffness and also the lateral crease recovery are significantly improved while the required longitudinal flexibility of the webbing is not materially affected.

Furthermore, the stiffness that is imparted to the webbing is of a springy nature rather than a rigid nature. This is particularly advantageous as a laterally rigid webbing will tend to cut the wearer and be uncomfortable in use, while a laterally springy webbing will give somewhat in use and so be more comfortable.

Control of the degree of lateral stiffness imparted to the fabric can be effected by selection of the incidence of impregnated weft yarns in the fabric, and preferably at least one in every successive four weft yarns is an impregnated, polyamide multifilament yarn. Control may also be effected by controlling the weight of impregnating agent present on the polyamide weft yarns, and desirably this ranges from 4% to 10% of impregnating agent by weight of yarn. A weight of 4% to 7% is particularly preferred, with 5% to 6% being the presently used range.

When the impregnating agent is a homopolymer of acrylic acid it can conveniently have a molecular weight within the range of 50,000 to 300,000 and an activity within the range of 20% to 50%. When a copolymer is used the additional monomer may conveniently be

methacrylic acid, desirably present in no more than 85% by weight. Preferred copolymers again have an activity within the range of 20% to 50%.

Prior to weaving, the polyamide yarn is conveniently impregnated by passing the yarn through a solution of the impregnating agent, and subsquently drying it at a temperature not exceeding 125°C. Below this temperature the only effect of the drying process is to drive off excess solvent and no curing or cross-linking of the impregnating agent occurs. The heat treatment of the woven fabric is then desirably effected at a temperature of from 132°C to 250°C with a dwell time of from 1 to 4 minutes.

Webbing in accordance with the invention is desirably woven on a conventional high speed needle loom. Any suitable weave pattern may be used, the commonest being a twill or a plain weave. Polyamide, for example nylon type 6 or 66, multifilament yarns destined for use as the weft yarns in the weaving process are passed through a bath containing a solution of the impregnating agent to be used. The preferred solvent is water, but non-aqueous systems may be used using, for example, methanol, ethanol or iso-propyl alcohol as solvent. Either before or after winding onto a storage member the impregnated yarns are dried at a temperature not exceeding 125°C in order to dry the solvent off. When fully dry they are cooled and then held at a temperature that must not exceed 100°C.

Prior to weaving, the weft yarns are coated with any suitable lubricant conventionally used in weaving in order to provide them with a surface friction sufficiently high to facilitate weaving on the high speed needle loom. The fabric is then woven from the polyester warp yarns, which may be either monofilament, or more preferably multifilament, from the lubricated and impregnated polyamide multifilament weft yarns and from other weft yarns if required, lubricated as necessary. A laterally stiff fabric will result from

the use of impregnated polyamide yarns for all the weft yarns. If the impregnated yarns are woven alternately with other weft yarns, for example polyamide multi-filament yarns that have not been impregnated, then a somewhat less laterally stiff webbing will be produced. Similarly, if only one weft yarn in three or one weft yarn in four is an impregnated yarn even lower lateral stiffness will be imparted. The less stiff webbings, although perhaps not suitable for motor vehicle use, nevertheless form webbings having very desirable properties for industrial safety harnesses.

After weaving, the fabric may be dyed if required, and then passed to an oven where it is heat treated at a temperature of from 130°C to 250°C for a dwell time of from 1 to 4 minutes, shorter dwell times being needed at higher temperatures. The presently preferred temperature is 220°C. Apart from linking the dye stuff, if present, to the yarn the heat treatment causes cross-linking of the impregnating agent and chemical bonding of this to the polyamide yarns. Accordingly, the polyamide yarns are stiffened to give them a spring-like stiffness, so imparting a springy lateral stiffness to the webbing. The acrylic acid homopolymer or copolymer does not chemically react with the polyester warp yarns, and indeed there is found to be a minimal bonding of the polymer to the warp yarns. Thus, the effect of the polymer is to enhance the lateral stiffness of the webbing without significantly reducing the longitudinal flexibility thereof.

The following comparative and specific examples illustrate the invention and its advantages. In all examples seat belt webbing of standard 48 mm width was woven in a twill weave on a high speed needle loom, using high tenacity polyester warp yarns and using 940 decitex nylon type 6 weft yarns treated as stated in the example. The woven fabric was dyed and finished, and held at a

temperature of 220°C for 1½ minutes. The cooled fabric was then tested for stiffness in both warp and weft directions using the Tinius Olsen method ASTM D-747 at a 6 inch-pound (5.21 cm-kg) capacity. Testing for crease recovery in both warp and weft directions was also carried out, using the Shirley Crease Recovery Method ASTM D-1295 at 20N load with creasing and recovery times each of 1 minute.

The results were as follows.

Example 1 (Comparative

Untreated nylon type 6 weft yarns were used, the webbing having the following properties:

Warp stiffness	44
Weft stiffness	29
Warp crease recovery	120°
Weft crease recovery	90°

Example 2

Nylon type 6 weft yarns were passed through a bath containing an aqueous solution of a homopolymer of acrylic acid having a molecular weight of 250, 000 diluted to an activity of 5% and dried. Conditions were regulated to give a dry weight increase on the yarn of 5%. Two ends of the yarn were used as the weft yarns in the weaving process. The webbing had the following properties:

Warp stiffness	55
Weft stiffness	51
Warp crease recovery	117°
Weft crease recovery	125°

Example 3

The procedure of Example 2 was repeated, except that the bath contained an aqueous solution of a homopolymer of acrylic acid having a molecular weight of 75, 000. The webbing had the following properties:

Warp stiffness	57
Weft stiffness	51
Warp crease recovery	98°
Weft crease recovery	140°

<u>Example 4</u>

The procedure of Example 2 was repeated, except that the bath contained an aqueous solution of a copolymer of 75% by weight methacrylic acid and 25% by weight acrylic acid. The webbing had the following properties:

Warp stiffness	49
Weft stiffness	44
Warp crease recovery	100°
Weft crease recovery	137°

From the foregoing examples it will be seen that the lateral stiffness of the webbings, i.e. the weft stiffness, showed an increase of from 51% to 76%, and that the weft crease recovery improved by from 39% to 56%. Such webbings are particularly suitable for use as vehicle safety harnesses.

CLAIMS:

1. A method of forming a woven fabric comprising interweaving polyester warp yarns with a plurality of weft yarns, at least some of the weft yarns being polyamide multifilament yarns impregnated with a non-cross-linked homopolymer or copolymer of acrylic acid, and after weaving subjecting the fabric to heat treatment to cause the impregnating agent to cross-link and chemically bond to the polyamide yarns.

2. A method according to claim 1 in which at least one in every successive four weft yarns is an impregnated, polyamide multifilament yarn.

3. A method according to any one of the preceding claims in which the impregnating agent is a copolymer of acrylic acid and methacrylic acid.

4. A method according to any one of the preceding claims in which the polyamide yarns are impregnated with from 4% to 10% by weight of the impregnating agent.

5. A method according to any one of the preceding claims in which the polyamide yarn in which the polyamide yarn is impregnated by passing the yarn through a solution of the impregnating agent and subsequently drying it at a temperature not exceeding 125°C.

6. A method according to any one of the preceding claims in which the heat treatment of the woven fabric is effected at a temperature of from 130°C to 250°C with a dwell time of from 1 to 4 minutes.

7. A woven fabric comprising polyester warp yarns interwoven with weft yarns at least some of which are polyamide multifilament yarns stiffened by a cross-linked homopolymer or copolymer of acrylic acid chemically bonded to the polyamide yarns, but not to the polyester yarns.

8. A woven fabric according to claim 7 in which at least one in every successive four weft yarns is a stiffened polyamide multifilament yarn.

9. A woven fabric according to claim 7 or claim 8 in which the stiffening agent is a copolymer of acrylic acid and methacrylic acid.

10. A woven fabric according to any one of claims 7 to 9 in which the stiffening agent is present on the polyamide yarn in an amount of from 4% to 10% by weight of yarn.